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Original Article

Residual kidney function and sleep quality in hemodialysis patients

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Abstract

Background: Sleep disorders frequently affect end-stage renal disease patients on dialysis. However, the relationship between sleep quality and residual kidney function is still unclear. Therefore, this study aimed to investigate this relationship.

Methods: In this analytical cross-sectional study, 225 patients who were referred to dialysis centers were studied, and based on renal function, they were classified into two groups with and without residual kidney function. The study employed the Pittsburgh Sleep Quality Index questionnaire to evaluate sleep quality. Multiple linear regression was utilized to determine the factors affecting sleep quality with a significance level consideration at $p<0.05$.

Results: The mean age of patients was 58.23 ± 13.50 years. 58.7% of patients were males. The problem of serious and very serious sleep in the Sleep latency and sleep duration has been more than other components. 72% of hemodialysis patients had poor sleep quality. In the multiple linear regression model, age (β = 0.442, 95% CI: 0.096, 0.788), sex (β = -0.847, 95% CI: -1.641, -0.054), Body mass index (β = 0.153, 95% CI: 0.058, 0.249) and dialysis duration (β = 0.097, 95% CI: 0.002, 0.192) were independently and significantly associated with sleep quality score. However, there was no statistically significant relationship between sleep quality and residual kidney function.

Conclusion: In conclusion, poor sleep quality is very common in patients undergoing hemodialysis. Therefore, sleep disorders in hemodialysis patients should be considered as one of the most challenging problems by healthcare providers, and early diagnosis and intervention are essential to improve sleep quality.

Keywords: Hemodialysis, Residual kidney function, Pittsburgh sleep quality index, Sleep disorders.

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Chronic kidney disease is one of the major health problems in the world today. As statistics show, the number of patients with end-stage renal disease in the world is around 2786000, while the disease is expanding as 6-7 % higher than the world population growth (1). Hemodialysis is used as the most common renal replacement therapy for ESRD patients (2). Practicing hemodialysis is associated with complications and patients receiving hemodialysis face many psychological stresses, including anxiety, depression, and multiple problems such as labor disorder, social isolation, and a decrease in quality of life in addition to many physiological changes (3). Sleep is an active state of unconsciousness produced by the body where the brain is in a relative state of rest and is reactive mainly to internal stimulus. Various theories have proposed to understand the purpose of sleep, encompassing the Inactivity theory, Energy conservation theory, Restoration theory, and the Brain plasticity theory. Each theory explores different perspectives on the functions and significance of sleep in relation to the brain (4).

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Throughout sleep, our body cycles through 4 different stages including both rapid-eye-movement (REM) and non-rapid eye movement (NREM) sleep. The body usually cycles through these stages on average 4 to 6 times, averaging 90 minutes in each stage. As the night progresses, fewer NREM stages occur, and the duration of REM sleep episodes increases (5, 6).

Sleep disorder is another important complication in hemodialysis patients and is a condition that is characterized by disrupting patterns or behaviors related to sleep (7). According to the studies, the prevalence of sleep disorders is about 80% in hemodialysis patients. Sleep apnea syndrome, periodic limb movement disorder, restless leg syndrome, excessive daytime sleepiness, increasing the severity of cardiovascular disease, weakness of the immune system, and the rise of mortality are more common in these patients (8-12).

The sleep quality in patients undergoing hemodialysis is lower compared to healthy general population. The results of studies show that 7 to 44 % of the general population experience low quality sleep. While its prevalence in patients undergoing hemodialysis is 44 to 83% (11). A study on the quality of sleep and quality of life of hemodialysis patients has shown that 71 % of these patients experience low quality sleep (13). In the study of Dashti et al., low quality sleep in these patients was reported as 87.7 % (14). Poor quality of sleep-in short-term causes boredom, reduction of memory power, reduction of the level of consciousness, reduction of the level of cognitive ability, reduction of the strength of the immune system, nap during the day, dizziness, blurred vision, and in long-term causes heart failure, diabetes, obesity, and eventually accelerated aging. It also affects work and social activities, leisure, temper, communication with others, sex activities, enjoyment of life, and the positive daily functioning of an individual (15).

CKD often have comorbidities such as diabetes, hypertension, cardiovascular disease, and obesity. These conditions are linked to sleep disorders and create a complex interplay that can further deteriorate residual renal function. Clinically, enhancing sleep quality can be accomplished by addressing various factors, including pain management, depression treatment, and reducing systemic inflammation (16).

Residual renal function in dialysis patients is significantly related to the health condition and the overall health of the patient so that not only makes clearance of small particles possible but also plays an important role in the balance of body fluids, phosphorus control, and uremic toxins with medium molecular weight and show a strong inverse relationship with calcification of heart valve and its hypertrophy in dialysis patients. Reduction of the residual renal function also contributes significantly to anemia, inflammation, and malnutrition in patients under dialysis. Most importantly, residual renal function is a powerful predictor factor for mortality, especially in patients under peritoneal dialysis (17). The importance of residual renal function in patients undergoing peritoneal dialysis is well understood, but there have been few studies on patients undergoing hemodialysis (18). Due to the importance of sleep disorders on the quality of life as well as the high prevalence of chronic renal diseases and lack of information and studies on this issue in the country, the present study aimed to investigate the relationship between residual renal function and sleep quality in patients undergoing hemodialysis.

Methods

Study design and data collection: The present analytical study examined 225 hemodialysis patients who referred to dialysis centers in Rasht (in Guilan province) in 2020. After obtaining research ethics approval from Guilan University of Medical Sciences, a list of all hemodialysis centers was compiled and the researchers referred to these centers to choose the research sample.

The research inclusion criteria included having all ESRD patients who underwent hemodialysis at Rasht academic medical centers. The exclusion criteria, however, included having patients with nocturnal symptoms due to other diseases, such as congestive heart failure, unstable angina, active arthritis and chronic obstructive pulmonary disease, together with having patients with a BMI greater than 35 and patients with known or treated sleep disorders.

For the present study, we divided the participants into two groups of RKF + and RKF -. People with a history of urinary excretion were assigned to the group named *Residual Renal Function (RKF +)* and those without urinary excretion were assigned to the group called *Without Residual Renal Function (RKF-).* Upon obtaining informed consent, we collected patients' necessary demographic information, such as age, gender, level of education, occupation, BMI, history of smoking, history of hypertension, history of diabetes, and patient urine sample (a 24-hour urine collection). Glomerular filtration rate (eGFR) was estimated by the Cockcroft-Gault formula (18).

Sleep quality measurement: Sleep quality was measured by the Pittsburgh Sleep Quality Index (PSQI) questionnaire (19). This self-report scale examines sleep quality over the past month and includes 19 questions in seven sections, including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication and daytime dysfunction. Scores of the seven components are summed to produce a global score and the response option ranges from 0 (better) to 3 (worse). In other words, the response options are scored as *no sleep difficulty* (score 0), m*oderate sleep difficulty* (score 1), *serious sleep difficulty* (score 2) and *severe sleep difficulty* (score 3). If the sum of the scores for the seven components is less than 5, this suggests good sleep quality. In contrast, a score of 5 or more indicates low sleep quality. Beckhouse et al. (20) validated the scale and its reliability was reported to be acceptable. The validity and reliability of the questionnaire have also been confirmed in Iran (21-22).

Ethical Approval: The study procedures adhered to the ethical standards set by the Guilan University of Medical Sciences Committee (Ethical code: IR.GUMS.REC.1399.433) and aligned with the 1964 Helsinki Declaration and its subsequent amendments or equivalent ethical standards. Written informed consent was obtained from all patients, and their medical records were reviewed while maintaining confidentiality by preserving names and details.

Data analysis: Continuous variables were described as mean ± standard deviation, whereas categorical variables as frequency and percentage. The independent sample t-test or the Mann–Whitney U-test was performed to compare the continuous variables between two groups. The chi-square test and Fisher's exact test were used for categorical variables. Multiple linear regression was used to determine the factors affecting sleep quality. The significance level was reported to be p <0.05 and the software used for data analysis was STATA.14.

Results

During the study period, 225 patients with hemodialysis, including 132 men and 93 women with a mean age of 58.23±13.50 years were studied. 162 (72%) hemodialysis patients experienced poor sleep quality. Female patients with low sleep quality outnumbered male patients (78.5% vs. 67.42%); however, the difference was not statistically significant (*P* = 0.069).

The BMI of patients with low sleep quality was significantly higher, compared to patients with good sleep quality (25.4±61 vs. 23.30±75.93; *P*= 0.005). Also, frequency of patients with low sleep quality in overweight people (81.4%), obese (78.4%) people and slim (65.18%) people outnumbered people with normal BMI (50.0%). In other words, patients experiencing low sleep quality exhibited a higher prevalence of abnormal BMI. Refer to table 1 for demographic and laboratory details of hemodialysis patients in the study.

As table 2 shows, the mean (standard deviation) of the total score of sleep quality was 6.4. Among the components of sleep quality score, sleep efficiency, use of sleep medication and daytime dysfunction had the lowest mean. In contrast, sleep disturbance, sleep duration and sleep latency had the highest mean. Sleep disorders increase when the sleep score increases.

Table 1. Demographic characteristics and laboratory parameters

Characteristic		N=225	Sleep Quality		P-value
			Poor (n=162)	Good (n=63)	
Age, year (Mean±SD)		58.23 ± 13.50	59.98 ± 13.44	56.30 ± 13.59	0.092
Sex n (%)	**Male**	132 (58.7)	89 (67.42)	43 (32.58)	0.069
	Female	93 (41.33)	73 (78.49)	20 (21.51)	
BMI, kg/m²		25.15 ± 4.04	25.61 ± 4	23.75 ± 3.93	0.005
Duration of dialysis (Year)	**<1**	26 (11.56)	19 (73.08)	7 (26.92)	0.755
	1-3	109 (48.44)	76 (69.72)	33 (30.28)	
	>3	90 (40.00)	67 (74.44)	23 (25.56)	
Kt/V		1.35 ± 0.29	1.36 ± 0.30	1.32 ± 0.27	0.177
Ferritin, ng/mL		457 ± 350.98	459.99 ± 371.58	452.09 ± 294.06	0.440

Characteristic	N=225	Sleep Quality		P-value
		Poor (n=162)	Good (n=63)	
ESR, mm/hr	32.41 ± 22.71	33.17 ± 22.71	30.46 ± 22.77	0.422
CRP, mg/L	8.40 ± 11.56	8.73 ± 11.72	7.57 ± 11.19	0.501
BUN, mg/dL	58.77 ± 14.44	58.35 ± 14.46	59.86 ± 14.44	0.483
Alb, g/dL	3.76 ± 0.41	3.74 ± 0.41	3.82 ± 0.42	0.183
P, mEq/L	4.47 ± 0.84	4.43 ± 0.76	4.57± 1.10	0.275
Ca, mEq/L	8.84 ± 0.86	8.89 ± 0.87	8.73 ± 0.83	0.112
iPTH, pg/mL	241.15 ± 253.80	237.83 ± 259.22	249.66 ± 241.10	0.754
GFR	6.98 ± 3.70	7.11 ± 4.04	6.65 ± 2.63	0.404

BMI: Body mass index, Kt/V: Clearance time/ Volume, Hb: Hemoglobin, ESR: Erythrocyte Sedimentation Rate, CRP: C - reactive protein, BUN: Blood urea nitrogen, ALB: Albumin blood, P: Phosphate, Ca: Calcium, iPTH: intact parathyroid hormone, GFR: glomerular filtration rate.

The results of Mann-Whitney U test showed that the total score of sleep quality and its components was not statistically significant in the two groups of patients with and without renal residual function. Table 3 indicates that sleep quality scores between male and female patients were different. The mean and median scores of sleep quality were higher in female patients (P= 0.002), implying that in the group without renal function, female patients had worse sleep quality, compared to male patients. Significant differences were found between males and females in terms of most components of sleep quality in the group without residual renal function (p <0.05). Table 4 shows the results of linear regression concerning factors relevant to sleep quality in the subjects.

In the multiple linear regression model, age (β = 0.442, 95% *CI*: 0.096, 0.788), gender (β = -0.847, 95% *CI*: -1.641, -0.054), BMI (β = 0.153, 95% *CI*: 0.058, 0.249), and the duration of dialysis (β = 0.097, 95% *CI*: 0.002, 0.192) were independently and significantly associated with sleep quality score. Nonetheless, no significant relationship between sleep quality and residual renal function was observed.

Table 2. Statistical indicators of the total score of sleep quality and each of its components in the studied samples

Components	Score	Mean ± SD	CI= %95	
			Lower Bound	Upper Bound
Subjective sleep quality	0-3	1.1 ± 0.81	1.00	1.22
Sleep latency	0-3	1.22 ± 1.12	1.08	1.37
Sleep duration	0-3	1.22 ± 0.90	1.10	1.34
Habitual sleep efficiency	0-3	0.20 ± 0.13	0.00	0.04
Sleep disturbances	0-3	1.23 ±0.53	1.16	1.30
Use of sleeping medication	0-3	0.60 ± 1.16	0.45	0.75
Daytime dysfunction	0-3	0.98 ± 0.88	0.87	1.10
Total score of sleep quality	0-21	6.38 ± 2.96	5.99	6.77

SD: Standard deviation, CI: Confidence intervals.

Table 3. Comparison of sleep quality in patients with and without renal residual function by sex

Components		Residual Kidney Function (n= 225)					
		Negative (n=169)			Positive (n=56)		
		Female	Male	p-value	Female	Male	p value
Subjective sleep quality	Mean	1.29	0.77		1. 2	1.08	
	SD	0.77	0.76	0.003	0.83	0.91	0.526
	Median	1.00	1.00		1.00	1.00	
Sleep latency	Mean	1.56	1.04		1.35	1.10	
	SD	1.19	1.05	0.004	0.99	1.07	0.121
	Median	2.00	1.00		1.00	1.00	
Sleep duration	Mean	1.33	1.19		1.05	1.16	
	SD	0.91	0.90	0.338	0.89	0.88	0.619
	Median	1.00	1.00		1.00	1.00	
Habitual sleep efficiency	Mean	0.03	0.00		0.05	0.02	
	SD	0.16	0.00	0.103	0.22	0.17	0.670
	Median	0.00	0.00		0.00	0.00	
Sleep disturbances	Mean	1.30	1.12		1.50	1.22	
	SD	0.54	0.51	0.029	0.51	0.54	0.071
	Median	1.00	1.00		1.00	1.00	
Use of sleeping medication	Mean	0.53	0.57		0.85	0.67	
	SD	1.13	1.14	0.835	1.35	1.19	0.619
	Median	0.00	0.00		0.00	0.00	
Daytime dysfunction	Mean	1.15	0.83		0.95	1.06	
	SD	0.88	0.85	0.018	0.83	0.92	0.650
	Median	1.00	1.00		1.00	1.00	
Total score of sleep quality	Mean	7.19	5.71		6.95	6.19	
	SD	3.07	2.84	0.002	2.54	2.84	0.198
	Median	7.00	5.00		8.00	6.00	

SD: Standard deviation

Table 4. Multiple linear regression model to determine the factors affecting sleep quality in patients undergoing hemodialysis [a, b]

Predictors	Unstandardized β	Standard Error	95%CI	P-value
RKF	0.422	0.276	-0.122, 0.965	0.127
RKF2, positive	-0.013	0.511	-1.020, 0.994	0.980
Age	0.442	0.176	0.096, 0.788	0.013
Sex, male	-0.847	0.403	-1.641, -0.054	0.036
BMI	0.153	0.049	0.058, 0.249	0.002
BUN	0.019	0.013	0.007, 0.045	0.152
K/TV	0.934	0.674	-0.394, 2.262	0.167
Duration of dialysis	0.097	0.048	0.002, 0.192	0.045

[a] β, regression coefficient; CI, confidence interval. [b] Dependent Variable: Total score of sleep quality. RKF: Radial Keratotomy, Hb: Hemoglobin, BMI: Body mass index, BUN: Blood urea nitrogen, K/TV: Clearance time volume

Discussion

Sleep is a fundamental biological need for maintaining overall physical and mental well-being. Poor sleep quality adversely impacts emotions, cognitive functions, motivation, and concentration, leading to reduced appetite and heightened levels of anxiety, nervousness, and depression (19). In the context of dialysis patients, sleep disorders pose a significant concern, as sleep deprivation is linked to weakness, cognitive impairment, and a diminished quality of life. Moreover, it elevates the risk of cardiovascular complications and mortality in adult dialysis patients with chronic kidney disease (20).

Studies indicate a widespread prevalence of sleep disorders in end-stage renal disease patients undergoing dialysis, ranging from 39% to 80% (21). Given the negative impacts of sleep disorders on life quality and a high prevalence of chronic renal disease, together with the lack of information and sufficient studies on this matter in Iran, this study investigated the relationship between residual renal function and sleep quality in hemodialysis patients. In this research, 72% of the patients experienced poor sleep quality, suggesting that a high number of patients have sleep disorders. Past research suggests that the prevalence of sleep disorders is 64 to 87% (21-25). The results of the present study are not at odds with those of the past research. Overall, the conclusion which can be made from this study and the existing literature is that poor sleep quality and sleep disorders are major concerns among hemodialysis patients. Effective measures should therefore be taken to improve the sleep quality of these patients.

Recent epidemiological and experimental studies have indicated to the reciprocal association between chronic renal disease and sleep disorders. The study by Chang et al., showed that when sleep quality starts to plummet, renal dysfunction happens, and consequently, integrated management of CKD patients should become a priority so as to prevent the progression of renal dysfunction and maintain good sleep quality (16).

The study by Kang et al. also reported that sleep apnea was quite common in peritoneal dialysis patients and was significantly associated with low RKF (26). For the present investigation, no significant relationship was found between residual kidney function and sleep quality. Given the high prevalence and great risk of sleep disorders in HD patients, active monitoring at the early stage of dialysis in HD patients is of importance. First, maintaining RKF deems important because RKF is essential for proper fluid management and salt removal in hemodialysis patients. When RKF is eliminated, active fluid management through converting to HD can reduce or prevent sleep disorders in HD patients (26). In the present research, age was independently associated with sleep quality, that is to say, sleep disorders in patients increase with age. This finding aligns with similar findings reported in other studies within this research domain (26-28). The reason can be ascribed to the increasing incidence of comorbidities and depression as a result of increasing age in dialysis patients (29). The findings also illustrated there is a relationship between gender and sleep quality as sleep disorders are more prevalent in women, which is in line with the findings of Pai et al. (30). However, Unruh et al. reported that sleep disorders were more common in men than women (31). The analysis of the relationship between the studied variables and sleep quality revealed a statistically significant relationship between BMI with sleep quality in hemodialysis patients. Higher BMI was correlated with poorer sleep quality. This aligns with the results of a 2017 study by Mehrabi et al, which found that overweight and obese hemodialysis patients exhibited lower sleep quality compared to those with a normal BMI or underweight patients (32).

Mohammadi et al. found that the association between dialysis adequacy and sleep quality is inverse as increased dialysis adequacy index (KT / V) leads to a low sleep quality score, and consequently, improved sleep quality (33). In contrast, our study, together with other studies (11, 28, 34) found no significant association between dialysis quality and sleep quality. The results of this paper suggest that there is a negative association between dialysis duration and sleep quality. Therefore, by increasing the average duration of dialysis, the quality of sleep decreases. The results of two studies by Tel et al. and Sabet et al. are consistent with our findings in this matter (21, 35). This research had several limitations. The sample was small and the study was conducted with no control group. Therefore, future studies should rely on a larger sample size. Additionally, because this was a cross-sectional study, we cannot determine the cause-and-effect relationship between the variables and sleep quality. Also, sleep disorders were assessed with subjective measures since objective measures of sleep disorders through polysomnography were impossible. In conclusion, our findings reveal a high prevalence of poor sleep quality among hemodialysis patients, highlighting sleep disorders as significant challenges. Therefore, healthcare providers should be wary of these issues, emphasizing the importance of interventions to enhance patients' sleep quality. Additionally, independent predictors of poor sleep quality include age, gender, BMI and duration of dialysis.

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